55~58. Studies on Silicone Resins. (I-IV)

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All the following four reports are the studies on the methylethyl and ethylmethyl polysiloxane varnishes which are under preparation on trial at the Laboratory of Shimazu Mfg. Co., Kyoto. And the ratios of alkyl radical (R) to silicon (Si) in these silicone varnishes are 1.25, 1.3, 1.4 and 1.5.

Part I. On the Electrical Properties of Silicone Varnish

(1) Relation between the insulating resistance and the temperature:

At room temperature, the difference of insulation resistance between silicone varnish and pure organic varnish is very small, but at high temperature, it becomes larger. For instance, the resistivity of W-25 varnish is 10^{11} ohm-cm at 100°C, while that of methyl-ethyl silicone varnish of which R/Si is 1.4, is 10^{12} ohm-cm at 230°C. The more the silicon varnish is dried, the better its insultion becomes.

(2) Relation between the dielectric strength and thickness of film:

By measuring the dielectric strength of these varnishes we found that the relation between puncture voltage and film thickness at room temperature could be expressed as, $V=Kd^{\frac{1}{2}}$, where V is puncture voltage in KV, d is thickness of film in mm, K is material constant; in this case the value of K is 24−32. This value is nearly equal to that of W-25 varnish. But in high temperature silicone varnish will have a higher dielectric strength.

(3) Characteristics at high frequency:

Power factor, and dielectric constants of various samples of which degree of drying (or polycondensation) were different respectively were measured at the frequency from 100 KC to 10 MC. The power factor of one kind of varnishes changes from about 8% to 0.25%, as it is dried. But the drying condition has little influence on the dielectric constant.

Part II. On the Contact Angle of Silicone Resin to Water.

In order to obtain the numerical value of the water repellency of silicone resins its contact angle to water was measured. There are several methods to measure the contact angle. Among them, we adopted so-called tilting plate method, and built up an apparatus resembled Nietze's device.

As it is well known, at the measurement of contact angle, there are two kinds of contact angles—so-called advancing and receding angle—which are not equal. And there is no fixed theory which angle must be adopted as contact angle. Whereas we found that the difference of two kinds of angles were available to find the degree of drying, and following conclusions were obtained from the difference of these angles.

(1) As varnish dries, the difference of these angles becomes smaller.

(2) As it dries, both angles reach nearly a constant value—advancing angle reach constant value earier than receding one—and the more it dries, the smaller the difference becomes.

(3) At the condition at which a receding angle reach nearly a constant value, the surface of the varnish becomes such as that our fingers don't feel sticky.

(4) By measuring contact angle we will be able to find the fact that poly-condensation reaction occurs gradually even at room temperature.

The measured values of contact angles are as follows:

In the case of conciderablly dried varnish, the advancing angle is 100°, receding one is 80°; hence their mean value becomes 90°. When the varnish contains much solvents, advancing angle is 110°, receding one 70°: and the mean value becomes 90°. The value of conta t angle of silicone resin manufactured in America are reported to be 90–110°. From these data the conclusion that our silicone varnish may have the same order of water repellency as American product, can be obtained.

Part III. On the Silicone Resin Coated Wire

The difficult problem in the manufacture of silicone resin coated wire (silicone enamelled wire), was the fact that the first film of the silicone varnish repelled the second silicone varnish. This might occur from the reason that the first film repelled the water which was given out at the condensation of the second film. And so we coated the varnish over the film before it dried enough, and succeeded to coat layer by layer.

We tested our silicone resin coated wire according to the rule of JES. They passed the pin hole test, the elongation test and the winding test. And we tested the resisting properties to H_2SO_4, HNO_3, and NaOH. Our samples don't change at all by H_2SO_4, but swell and dissolve a little by HNO_3, and are corroded and entirely grow pin holes by NaOH.

It is an interesting fact that the silicone resin coated wire shows golden colour at some drying temperature. We presume that a cuprous oxide film grows and its reflected light shows that golden colour, because the colours appeared with the rise of temperaure following the order of a reflected light of the cuprous oxsde film as it becomes gradually thick.

Several coils for high frequency were prepared with this wire; after being immersed in water for six hours, their Q values at 2 mega cycles were measured. (The Q of the coil made of a steatite bobbin coated by the silicone resin on which the silicone resin coated wire was wound was 125.) But the Q of the coil of a bakelite bobbin which common enamelled wire was wound was 80. These results promise the wide use of the silicon resin coated wire in our country rich in humidity.

Part IV. On the Silicone Resin Immersed Glass Cloth.

For the purpose of manufacturing glass insulating electrical machines, we are studying the silicone resin immersed glass cloth. We also invented a semi-transparent thin plate (silicone paper) like mica, which was produced by the following method. Short glass fibers are immersed in the silicone resin varnish, and are rolled by roller, and then are heated.

The properties of the samples of glass cloth and silicone paper were measured respectively.

The relation between the insulating resistance and temperature is located between the characteristics of glass and resin. These properties of the glass of which sizing is eliminated by boiling, are better than those of which sizing is eliminated by heating.

We immersed the sample in water and measured the decrease of insulating resistance. Within 20 hours the resistance was unmeasurable high value by our apparatus, and after about 40 hours it became 1.5×10^{13} ohm-cm, and then it decrease rapidly.

The relation between the dielectric strength and temperature was measured. Our invented silicone paper showed 6 KV/0.29 mm at 240°C.

The electrical and mechanical properties of our sample are shown in the following table. The right end is the laminated plate produced by G. E. Co.

Silicone Varnish	R/Si 1.5	R/Si 1.4	R/Si 1.4	G. E. Co. No. 11523
Base Material	Short Glass Fiber	Short Glass Fiber	Glass Cloth	Glass Fiber Laminated. Plate
Thickness (mm)	0.24	0.30	0.50	3.0
Tensile Strength Kg/cm^2	160	—	300	800
Insulation Resistance Ω-cm	1×10^{12} (at 150°C)	—	6.2×10^{12} (at 150°C)	2×10^{11}
Dielectric Strength V/0.01mm	212	169	50	120
Dielectric Constant (1 MC)	2.03	2.81	2.46	2.88
Power Factor (1 MC)	0.0012	0.0065	0.0114	0.0015

59. Aging Phenomenon in Poval Filaments.

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A dural change of mechanical properties in poval filaments,* obtained by semimolten-spinning were computed. The preserving condition of materials were as follows,

(1) Sealed in tubes at various temperatures. (15°C, 30°C, etc.)

(2) Opened to air at ordinary temperature. (30°C)